system must be free from chromatic aberration. Now let us, for simplicity, deal with two lenses in contact; let f, f' be their focal lengths, μ, μ' their refractive indices, and let $1/\nu$ $1/\nu'$ represent their dispersive powers, so that $\nu=(\mu-1)/(\mu_v-\mu_r)$, μ_v and μ_r being the indices for the rays it is desired to achromatise, while μ refers to some mean ray.

Then the condition for achromatism is

$$\frac{1}{\nu f}+\frac{1}{\nu' f'}=0.$$

Now it is shown in the book that for this case the condition that the field may be flat—Seidel's fourth condition—reduces to

$$\frac{1}{\mu f}+\frac{1}{\mu' f'}=0.$$

Thus the focal lengths must be of opposite sign, and the lens with least focal length—the concave lens that is in a photographic combination—must have the greatest refractive index. But, in order to satisfy the condition for achromatism, this same lens must have the greatest value for ν'.

Now achromatic lenses have usually been made by combining a convex lens of crown glass with a concave lens of flint; with such glasses, however, it is found that when μ is large ν is small, and *vice versâ*. Thus, for example, ordinary light flint has a greater refractive index than silicate crown glass, and hence an achromatic combination is possible; but since the value of ν for such flint is less than for crown, the combination when made will not give a flat field.

Dr. Lummer defines as an "old achromat" a pair of achromatised lenses made of such glass.

One of the results, however, of the experiments of Abbe and Schott at Jena has been the discovery that by the addition of barium salts a crown glass can be obtained having both a high refractive index and a high value for ν. Such a glass could take the place of the flint glass in an achromatic combination, and with this advantage, that the condition for flattening the field could be nearly, if not completely, satisfied.

The condition above given for a flat field was discovered by Petzval in 1843; in principle it had already been published by Airey ("Coddington's Optics," 1829). Von Seidel, however, was the first to point out that it was impossible with the lenses then available to satisfy both it and the condition for achromatism, and it was not until the Jena glass became available that an achromatic lens with a flat field was possible. Such lenses are called by Lummer "new achromats."

Having shown, in the first eight or nine chapters of the book, what are the conditions to be satisfied, Prof. Lummer proceeds to describe the various ways in which this is done in practice. The condition of no distortion is readily satisfied by combining two identical sets of lenses symmetrically placed into a double object glass with the stop midway between. These, if of the new "anomalous" glasses, can have a flat field. But such a combination will not be completely stigmatic; to secure this, other conditions must be satisfied besides those which are possible in a symmetrical combination, and the best result has been obtained by combining, in what is known as an anastigmatic-aplanat, a new achromat with an old achromat. The astigmatic effect of the old achromat is opposite to that of the new; hence by the combination it is possible to secure a flat image which is also stigmatic and achromatic, while, by adjusting the distance between the lenses and properly placing the stop, the condition of no distortion is satisfied.

Details of combinations satisfying these various conditions are given in the book, and not the least of Dr. Thompson's services are the chapters in which he calls attention to the excellent work done by various well-known English makers. His description of Dallmeyer's Tele-objective is specially welcome, while Miethe's two views of Munich from a distance of about two miles—the one taken with an ordinary lens, the other with his tele-objective—show what a powerful weapon the latter is.

The appendix contains some more detailed accounts of von Seidel's analysis, and also a valuable example of the computation of a lens.

The book is published by Messrs. Macmillan and Co. in their usual admirable style, and supplies a very real addition to the literature of a subject too much neglected in England. R. T. G.

OUR BOOK SHELF.

A Handy Book of Horticulture. By F. C. Hayes, M.A. Pp. xi + 225. (London: John Murray, 1900.)

THIS is a little book intended "for the class of fairly intelligent young men who are placed in sole charge of small gardens, who have little natural aptitude for gardening and no training, and who look in vain to their employers for teaching or suggestions of any kind." The questions naturally arise how such men come to have charge of gardens, and whether any book is likely to be of material service to them. For a class of better informed readers with a real interest in the subject the present book is better adapted, as the directions are simple and clear. The practical instruction conveyed is good, but, although the book is not intended for botanists, we may fairly look for accuracy and correct spelling of names.

In the following passages we have examples of loose writing, which are not the only ones that might be found:—

"The lilium is a popular family of hardy, bulbous flowers. No garden should be without a variety of them, but the species is so numerous that it would be impossible in one brief chapter to lay down general rules for their culture."

Here is another paragraph which is not remarkable for accuracy:—

"Speaking generally, a fern may be defined as a plant which bears leaves only and no flowers. The name of their order is Cryptogamia, *i.e.* hidden flowers; they have organs which produce spores, but the attractive petals are absent, and the spore cases are hidden away or take strange forms."

On the following page we have such misspelling as Calcidonicum and tigranum; elsewhere we find nemerosa, pyracanthus, azalias, Charles Lefebre; while the use or disuse of capital letters seems to be entirely a matter of caprice.

The Construction of Large Induction Coils; a Workshop Handbook. By A. T. Hare, M.A. Pp. 155. 35 illustrations. (London: Methuen and Co., 1900.)

THIS book, written by an amateur primarily for amateurs, will be found of the greatest use for all those, amateurs and professionals alike, who desire to construct Rhumkorf induction coils according to the most approved methods.

It is, indeed, so far as the present writer is aware, the only modern work which deals with the construction of large coils from a thoroughly practical standpoint. It describes in every detail the making of the apparatus, and contains much valuable information as to the general design of coils, the methods of winding and the processes of insulation, which hitherto have been the carefully preserved secrets of the very few makers of coils of the more powerful descriptions. Questions of cost are not omitted, while special chapters are devoted to contact breakers of the mercury, hand and electrolytic types.

The discovery of the Röntgen rays, and the important application that these have found in surgical and medical practice, together with the increasing employment of high tension electrical discharges in wireless telegraphy, spectroscopic analysis and other fields, have brought about a great demand for Rhumkorf coils of large size. The need for a book such as the one under review has therefore become increasingly felt of late years, and the only matter for regret is that the author did not give to the public the results of his experience at an earlier date.

The book is clearly written, well printed and well illustrated. A. A. C. S.

The Structure and Life-History of the Harlequin Fly (*Chironomus*). By L. C. Miall, F.R.S., and A. R. Hammond, F.L.S. Pp. viii + 196; plate and text illustrations. (Oxford: Clarendon Press, 1900.)

THE perfect insects of *Chironomus* are conspicuous objects on our windows, or may be seen dancing in swarms in the open air, and are often called "gnats," to which they have considerable resemblance; and, like gnats, the antennæ of the males are very plumose. The larvæ are found at the bottom of standing or slowly-running water, and those of some species are known, from their colour, as "blood-worms," while those of other species are green. The insects are easily collected and reared, and present many points of interest; and the work before us gives a very clear and fairly elaborate account of the structure and habits of these insects in their various stages. The life-histories of insects present an inexhaustible field for the investigations of any observers who care to devote their attention to this branch of entomology; and books like the present will give the beginner a very good idea of the best way to work on similar lines. Hitherto the Diptera, though one of the largest orders of insects, have been strangely neglected in England, and we have not even a good descriptive book on the order, though almost every Continental country has a good monograph in its own language. The interest felt in mosquitoes, however, at the present time will probably spread to other insects of the same order; and thus we are likely to see the study of their life-histories leading to that of the Diptera as a whole, instead of interest in the order generally, leading to researches into its life-histories, as has been the case with some of the other orders of insects.

The bulk of this work is too technical and too elaborate to admit of its being discussed in detail, and it contains much useful general information relating to allied species, nor are the parasites of the larvæ left unnoticed. One remark strikes us as specially interesting: "No insect is known to us which has more completely departed from the habits and structure of an air-breathing animal. Yet even here we find visible proof of descent from a terrestrial insect with branching air-tubes."

In an appendix we find a section on "Methods of Anatomical and Histological Investigation," and an additional note by Mr. T. H. Taylor on the swarming and buzzing of Harlequin flies. The book concludes with a good bibliography and index. W. F. K.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

On the Nature of the Solar Corona, with some Suggestions for Work at the next Total Eclipse.

IN an article on the corona, published in the November number of the *Astrophysical Journal*, I suggested a method by which the existence of the Fraünhofer lines in the spectrum of the corona might be detected. The method was based on the supposition that the light emitted by the particles, in virtue of their incandescence, so overpowers the reflected sun-light that the lines are invisible. That the coronal light is strongly polarised is well known, and there is scarcely any doubt but that the polarised light is reflected sun-light. If, now, a Nicol prism be placed before the slit of the spectroscope in such a position as to transmit the polarised radiations, these will be allowed to pass with almost undiminished intensity, while the emitted or unpolarised light will be reduced in intensity by one-half. The great change in the ratio resulting might easily be sufficient to bring out the dark lines distinctly. I feel firmly convinced that this experiment should be tried at the Sumatra eclipse of next May, for I have successfully accomplished it in the laboratory with an artificial corona. It was found that a gas flame in a strong beam of sun-light shone with a pure bluish-white light, due to the reflection or rather scattering of the sun-light by the minute carbon particles.[1] The flame thus illuminated showed the Fraünhofer lines distinctly, but by reducing the intensity of the sun-light a point was reached at which they disappeared, and the spectrum appeared continuous. The light scattered by the flame was found to be completely plane polarised in certain directions, giving us just the required conditions, namely, particles emitting a continuous spectrum, and scattering a polarised solar spectrum. In front of the slit of the spectroscope a Nicol prism was arranged in such a manner that it could be drawn into and out of position by a cord. The Fraünhofer lines could be made to appear by sliding the Nicol in front of the slit, and disappear by drawing it away. While it does not by any means follow that the use of a Nicol on the actual corona will bring out the lines, the experiment seems to be well worth trying, as it would furnish further information regarding the relative intensity of the emitted and reflected light.

Another interesting point is that the minute particles in the flame do not scatter the longer waves, the flame reflecting practically no red or orange light. Thus the Fraünhofer lines can only be traced to about the D lines. By reducing the intensity of the sun-light they disappear, first in the yellow, then in the green, blue and violet in succession. This indicates that our chances of detecting the lines in the spectrum of the corona will be greatest in the photographic part of the spectrum. Moreover, it appears to explain the absence of radiant heat in the light sent to us from the corona, the particles being too small to scatter these longer waves to any appreciable extent. Abbott, of the Smithsonian party at Wadesboro', found the corona cold in comparison with his bolometer, and infers from this that the corona neither reflects sun-light nor emits light in virtue of incandescence, expressing the opinion that the luminosity is analogous to that of vacuum tubes transmitting electric discharges. It seems to me that the polarisation of the coronal light makes this theory untenable, and that the absence of heat rays can be explained fully by the small size of the particles. I am aware that the absence of radiant heat in the *emitted* light has yet to be accounted for. My own notion, based on experiments which are now in progress, is that the reflected or scattered light is vastly in excess of the emitted, and that the absence of the Fraünhofer lines is more probably due to the line-of-sight motion of the particles than to simple drowning out by emitted light.

My experiments on the ratio of emitted to scattered light of a body brought to incandescence by powerful solar radiation are not yet completed, consequently I do not yet feel prepared to make any very positive statement in regard to this matter. A

[1] Since writing the above I have found that the reflection of light by a flame has been described by Mr. Burch and Sir George Stokes indepen dently. It was noticed also by Soret at a still earlier date (1875) as I have subsequently found.